# GROWTH CHARACTERISTICS OF PINYON-JUNIPER STANDS IN THE WESTERN GREAT BASIN

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# RESEARCH SUMMARY

Stem analyses in singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stands in Nevada and eastern California indicate that tree age does not directly affect either diameter or height growth rates. Diameter growth rates are governed primarily by competition, and height growth rates depend largely on genetic characterictics and approach to a site-dependent maximum height. Rates of stand basal area increment vary among stands, but tend to be constant with time within closed stands. Because of its constancy and direct relationship to productivity, stand basal area increment may provide a good index of site quality in closed stands. Total aboveground biomass accumulation rates tend to increase with time, even in older stands. In the absence of perturbations, biomass in pinyon-juniper stands would probably continue to accumulate at nearly constant or slightly increasing rates for several centuries.

# CONTENTS

# INTRODUCTION

A study of tree growth and stand development in pinyon-juniper (*Pinus monophylla-Juniperus osteosperma*) woodlands of the Great Basin was initiated in 1977. Meeuwig and Budy (1979)[1] measured, analyzed, and reported on three pinyon plots in the Sweetwater Mountains, 130 km (80 mi) south-southeast of Reno, Nevada. During the summer of 1978, five more plots were measured: three in the Paradise Range 190 km (120 mi) east-southeast of Reno, one in the Monitor Range 300 km (190 mi) east-southeast of Reno, and one more in the Sweetwater Mountains. These plots were located on firewood sale areas, but on sites with no evidence of recent cutting or other disturbance. Except for one plot in the Paradise Range, the plots were located in the oldest undisturbed stands that could be found in the sale areas. All five plots were predominately pinyon, but contained some juniper. Understory was sparse on all five plots.

# METHODS

The procedures followed in 1978 were essentially the same as those of the previous year, except no trees were weighed. The plots were 30 m square. A crown map was prepared for each plot, showing locations of all trees taller than 1 dm.

All trees taller than 2 m were felled and their total height was measured with a tape. Stump height was about 15 cm unless limbs or other irregularities made it necessary to cut above or below this height. On all felled trees, stem sections were taken at the stump, at about 3 cm diameter on the dominant leader and at two intermediate points on the dominant stem. The ages of these sections were determined by annual ring count and height-age curves were plotted for each tree. These curves were extrapolated to ground level to estimate tree age, and interpolated to determine past height at any particular time.

Stump diameters outside bark (d.o.b.) were measured with a diameter tape. A few trees had more than one stem at stump height. Equivalent diameters of these were calculated by taking the square root of the sum of the squared diameters of the individual stems.

Total aboveground biomass, foliage mass, and mass of wood in stems and limbs larger than 3 inches (76 mm) diameter were calculated for each tree using regression equations developed from data obtained in another study (Miller, Budy, and Meeuwig, in preparation). These equations are defined in appendix A.

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[1]Meeuwig, Richard O., and Jerry D. Budy. 1979. Pinyon growth characteristics in the Sweetwater Mountains. USDA For. Serv. Res. Pap. INT-227, 26 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Past diameters of each stumpsection were determined by measuring ring widths (to the nearest 0.1 mm) along a radial that appeared to best represent diameter growth. Stump diameters outside bark ($D_t$) at any time (t) in the past was calculated by

$$D_t = (\text{d.o.b.})\ \Sigma_t ri / \Sigma_p ri$$

in which d.o.b. is present diameter outside bark, $\Sigma_t ri$ is the sum of ring widths from the pith to time t, and $\Sigma_p ri$ is the sum of all ring widths along the radial. If there was more than one stem at stump height, ring widths were measured on the largest stem and the calculated equivalent diameter was used for d.o.b.

Basal area and total aboveground biomass of each tree were calculated by decades from 1860 to 1970 and also for 1965 to 1975, using the calculated past diameters and interpolated heights as inputs to regression models described in appendix B.

Stand basal area and biomass per hectare from 1860 to 1978 were calculated by summing the values of the individual trees and dividing by plot area (0.09 ha).

# RESULTS AND DISCUSSION

Elevation, slope, and aspect of the plots are listed in table 1. All eight plots are on skeletal soils derived from igneous parent material. Sweetwater plots S1, S2, and S3 were measured in 1977 and reported by Meeuwig and Budy (1979); and Sweetwater plot S4 was measured in 1978. Plots P1, P2, and P3 are in the Paradise Range near Gabbs, Nevada; and M1 is in House Canyon in the Monitor Range.

Except for plot P3, the stands sampled in 1978 were considerably older than the three sampled in 1977 (table 2). They apparently escaped the extensive cutting that took place in the Nevada woodlands during the latter half of the 19th century. Four plots showed no evidence of tree harvesting, other than some juniper-post cutting, even though they were surrounded by woodland that apparently had been cut over in the 19th century.

Table 1.--*Elevation, slope and aspect of the eight plots*

| Plot | Elevation | Slope | Aspect |
|---|---|---|---|
| | *m* | *Percent* | |
| S1 | 2 200 | 5 | N 80° E |
| S2 | 2 100 | 20 | N 40° E |
| S3 | 2 300 | 15 | S 60° E |
| S4 | 2 030 | 25 | N 15° W |
| P1 | 2 060 | 5 | N 6° W |
| P2 | 2 040 | 15 | N 55° E |
| P3 | 2 190 | 5 | N 85° E |
| M1 | 2 220 | 20 | S 60° E |

Table 2.--*Age distribution of trees taller than 2 m on the eight plots*

| Age class | S1 | S2 | S3 | S4 | P1 | P2 | P3 | M1 |
|---|---|---|---|---|---|---|---|---|
| *Years* | | | | | | | | |
| 41-60 | 1 | -- | 1 | -- | 1 | -- | -- | -- |
| 61-80 | 17 | 6 | 9 | -- | -- | -- | 4 | -- |
| 81-100 | 10 | 9 | 9 | 1 | 6 | 1 | 6 | -- |
| 101-120 | -- | 9 | 5 | 5 | 10 | 2 | 8 | 1 |
| 121-140 | 1 | 6 | 2 | 2 | 12 | 2 | 5 | 3 |
| 141-160 | 3 | 14 | 1 | 1 | 6 | 1 | 16 | 2 |
| 161-180 | -- | 12 | 3 | 2 | 2 | 2 | 10 | 6 |
| 181-200 | 1 | 1 | -- | 2 | 1 | -- | -- | 9 |
| 201-220 | -- | -- | -- | 2 | 3 | 1 | 1 | 6 |
| 221-240 | -- | -- | -- | 1 | 5 | 2 | -- | 5 |
| 241-260 | -- | -- | 2 | 1 | 6 | 2 | -- | 4 |
| 261-280 | -- | -- | 1 | 2 | 4 | 6 | -- | 15 |
| 281-300 | -- | -- | -- | 2 | 1 | 2 | -- | 9 |
| 301-320 | -- | -- | -- | 4 | 1 | 3 | -- | 4 |
| 321-340 | -- | -- | -- | -- | 2 | -- | -- | 1 |
| 341-360 | -- | -- | -- | 2 | 1 | 4 | -- | 1 |
| 361-380 | -- | -- | -- | 4 | 1 | 1 | -- | -- |
| 381-400 | -- | -- | -- | 1 | -- | 1 | -- | -- |
| 401-420 | -- | -- | -- | 1 | -- | -- | -- | -- |
| 421-440 | -- | -- | 1 | -- | -- | -- | -- | -- |
| Total | 33 | 57 | 34 | 33 | 62 | 30 | 50 | 66 |

The fifth plot (P3) was selected in a younger stand. Its age structure was nearly identical to that of plot S2 and similar to the other two Sweetwater plots measured in 1977.

On the basis of age structure, the eight plots can be divided into two groups: four relatively young and four relatively old. The four older plots have an all-age structure, but few young trees. The younger plots show a tendency toward all-age structure. Plot S3 is considered young even though it had four old trees that apparently had been left when it was cut over in the 19th century.

Canopy cover varied from 36 percent in plot S4 to 64 percent on plot S2 (table 3). Stand basal area ranged from 23.4 $m^2$/ha on plot S1 to 38.4 $m^2$/ha on plot S4. Stand basal area growth from 1966 through 1975 varied from 2.2 $m^2$/ha/decade on plot M1 to 5.3 $m^2$/ha/decade on plot S1.

Total aboveground biomass, wood mass, and foliage mass in metric tons per hectare on each plot, and the rate of total aboveground biomass accumulation are also presented in table 3. The figures for wood are based on the mass of ovendry wood (bark excluded) in stems and limbs larger than 76 mm (3 inches) diameter and provide an indication of the amount of cordwood. One cord contains about 1 metric ton of ovendry wood, not counting bark.

Crown maps and tree data for the five plots measured in 1978 are in appendix C and appendix D. For crown maps and tree data for plots measured in 1977, see Meeuwig and Budy (1979).

## Height Growth

In general, the plots sampled in 1977 showed appreciable variation in rates of height growth among trees, even among dominants; but each tree grew in height at a fairly constant rate throughout most of its life. There was little indication that height growth slowed down as the trees aged. The plots sampled in 1978 showed even more variation in height growth rates among dominants, but few of the dominants have straight-line height growth curves (fig. 1 and 2). Some have the typical curve, exemplified by tree No. 48 on plot P1, in which height growth rate decreases as height increases. Some, like tree No. 43 on plot P1, grow rapidly at first and then slow down to a lower rate of height growth that is sustained for one or two centuries. Others have erratic rates of height growth that may, like that of tree No. 5 on plot S4, increase with time.

Table 3.--*Canopy cover, stand basal area, biomass, and growth rates on the eight plots*

| | Plot | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | P1 | P2 | P3 | M1 |
| Canopy cover (%) | 49 | 64 | 60 | 36 | 52 | 56 | 58 | 40 |
| Stand basal area ($m^2$/ha) | 23.4 | 35.4 | 34.8 | 38.4 | 33.0 | 32.1 | 29.9 | 29.1 |
| Total aboveground biomass (MT/ha) | 80 | 116 | 121 | 118 | 86 | 102 | 96 | 60 |
| Wood (MT/ha) | 30 | 47 | 54 | 55 | 33 | 42 | 35 | 19 |
| Foliage (MT/ha) | 13 | 15 | 14 | 10 | 10 | 13 | 13 | 9 |
| Decadal growth (1966-1975) | | | | | | | | |
| Stand basal area ($m^2$/ha/10 yrs) | 5.3 | 3.6 | 3.8 | 2.5 | 2.7 | 2.7 | 3.4 | 2.2 |
| Total aboveground biomass (MT/ha/10 yrs) | 20.8 | 12.3 | 13.4 | 9.3 | 8.4 | 10.6 | 13.4 | 5.5 |

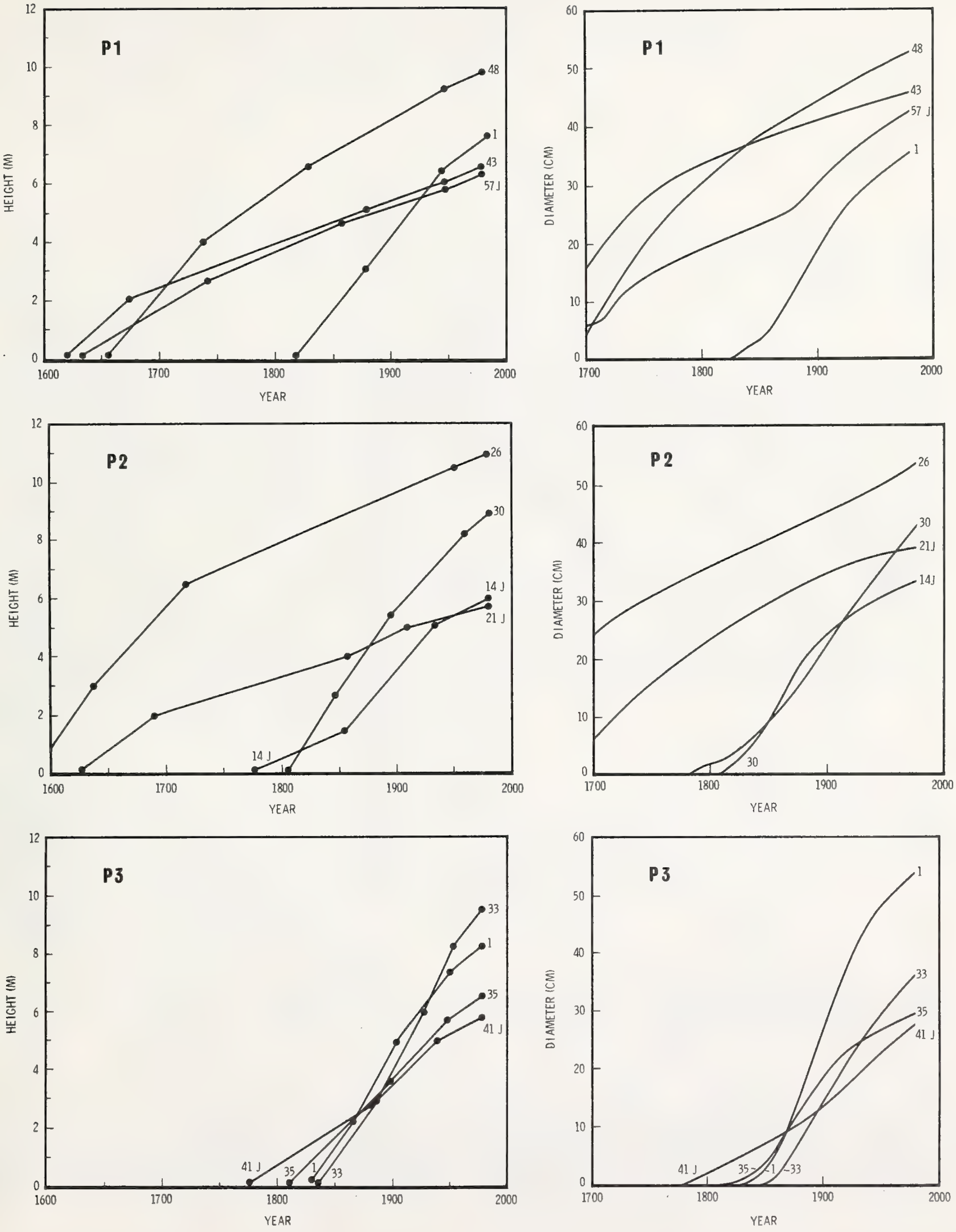


Figure 1.--Heights and stump-height diameters through time of selected trees on the plots in the Paradise Range. Selected trees include the oldest and tallest pinyons and the oldest and tallest junipers on each plot. Junipers are identified by the letter J.

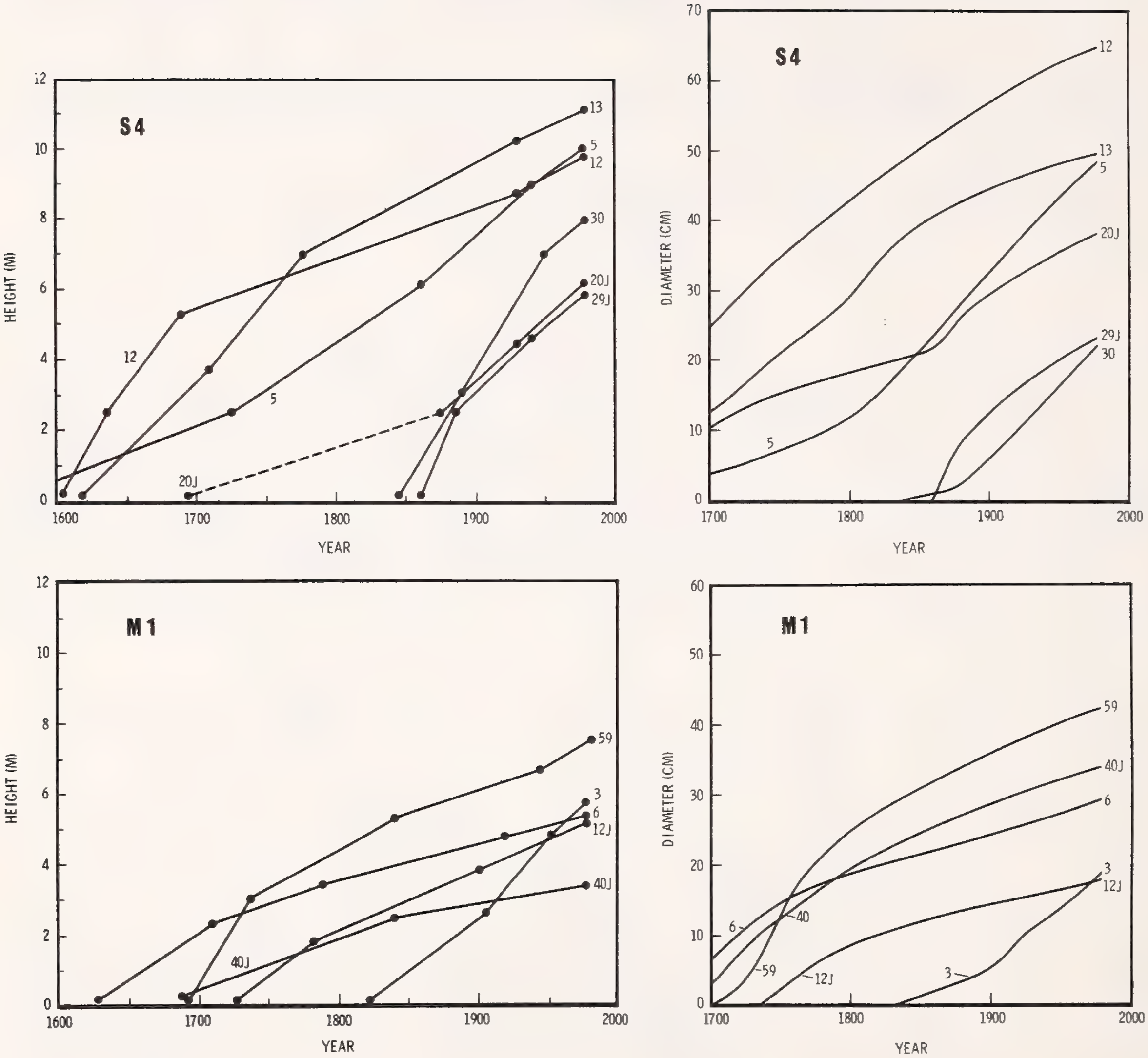


Figure 2.--Heights and stump-height diameters through time of selected trees on plots S4 and M1. Selected trees include the oldest and tallest pinyons and the oldest and tallest junipers on each plot. Junipers are identified by the letter J.

Junipers tended to have lower height growth rates than pinyon, but the two junipers in plot S4 show that juniper is capable of height growth rates comparable to pinyon. A post had been cut from the main stem of juniper No. 20 on this plot about 100 years ago and the present top is a lateral branch that took over. Its height growth rate equaled that of the much younger juniper No. 29.

## Diameter Growth

As reported for the 1977 plots, diameter growth rates did not decrease appreciably with age in truly dominant trees. Reductions in diameter growth were caused by competition.

Tree No. 5 on plot S4 (fig. 2) is particulary interesting. In 1750, it was severely suppressed, about 200 years old, only 26 dm tall, only 8 cm diameter at stump height, and nearly dead. It was gradually released from suppression sometime between 1750 and 1800. It recovered slowly and eventually became one of the fastest growing dominants in the stand. What happened to the suppressing overstory back in the 18th century is unknown; there was no evidence of fire damage to the surviving trees. Similar, but less spectacular, responses to release have been observed in other pinyons.

## Stand Basal Area

Radial growth of the individual trees on the plots fluctuated and generally decreased as competition increased, but, once the trees fully dominated, stand basal area growth on each plot became remarkably constant (fig. 3). The magnitude of this constant rate is determined by site quality.

Theoretically, there is a maximum basal area for each stand, and, as this maximum is approached, stand basal area increment decreases through reduction in growth of individual trees and through mortality. Other than seedlings and a few saplings, there has been no evident mortality on six of the plots in the past 100 years or so. The other two plots, S4 and P2, each had one pinyon snag. These trees were 220 and 280 years old at time of death and had stump diameters of 25 and 30 cm. Both had been growing very slowly for more than 100 years prior to death and apparently died because of localized overcrowding.

All of the sampled stands, even the oldest ones, are well below maximum basal area. There are no indications of impending reduction in basal area increment on any of the plots, except possibly two of the younger plots, S2 and P3.

The four younger plots all have higher basal area growth rates than the four older plots. This is because they are on better sites, not because young stands grow faster than old ones. All available evidence indicates that basal area growth rates on the older plots were no greater when they were young. It would be desirable to sample older stands on better sites, but none have been found so far. Virtually all accessible good sites must have been cut over in the 19th century.

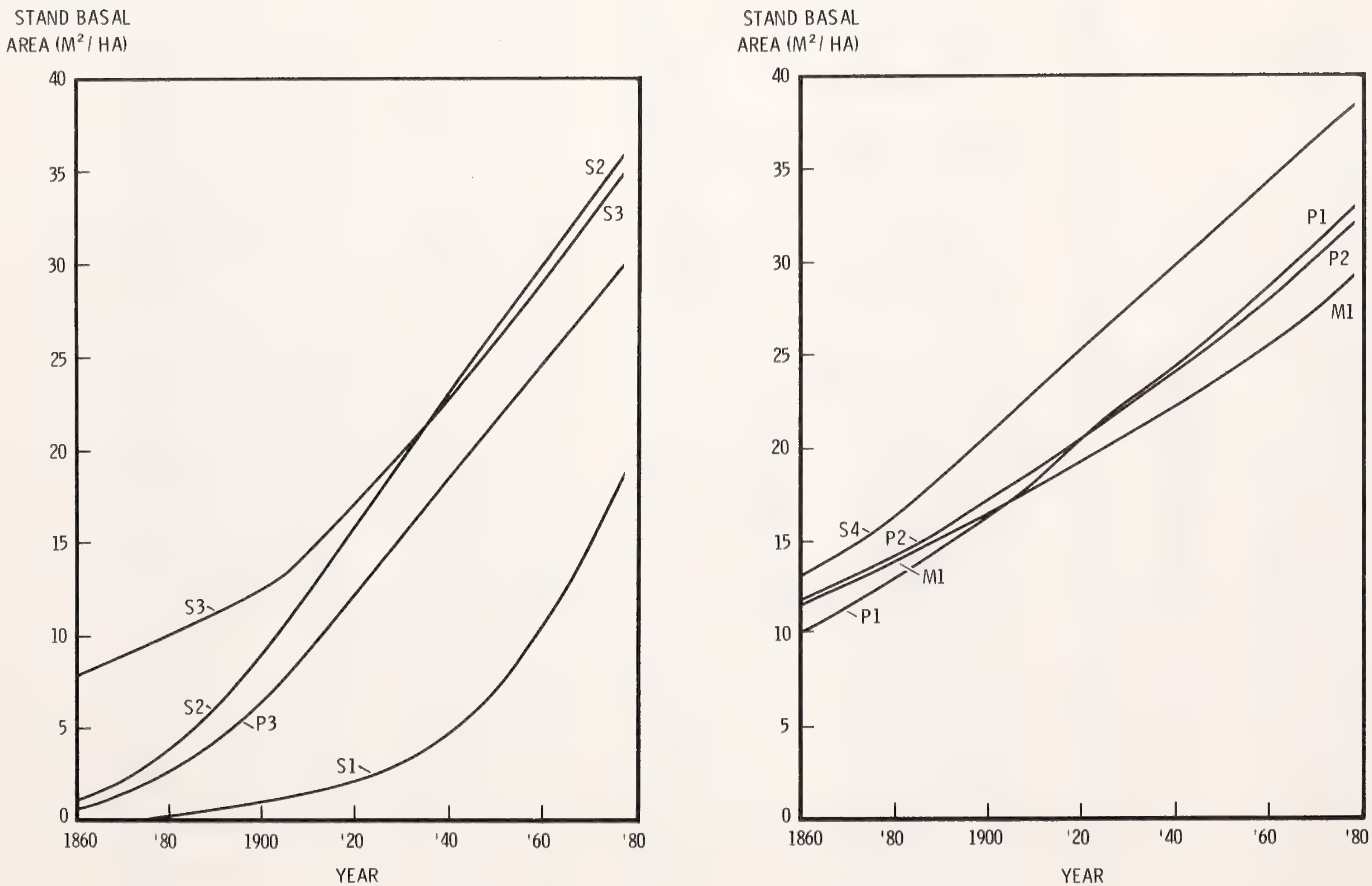


Figure 3.--Stand basal area on the eight plots from 1860 to 1978.

## Total Aboveground Biomass

Stand biomass curves (fig. 4) follow patterns similar to basal area curves (fig. 3). The main differences are in the relative positions of the curves and the tendency for continuing increases in biomass growth rate after basal area increment has stabilized. The changes in relative positions of the curves are caused mainly by differences in tree height characteristics. Plots P1, P2, and M1 are very close in basal area, but P2 has the tallest trees and M1 has the shortest; hence the separation of their biomass curves. The tendency for biomass growth rate to continue to increase after basal area increment ceases to increase is due to continued height growth.

Regardless of age structure, all plots have been accumulating biomass at an increasing rate; however, biomass accumulation rates must eventually decline. On the basis of these plots, the time when that decline would begin is unpredictable. Mortality must increase appreciably to bring about a decline in biomass accumulation rate.

# CONCLUSIONS

The plots measured in 1977 were all in relatively young, pure pinyon, stands on good sites. Except for plot P3, the plots measured in 1978 were in older stands, containing some juniper, on poorer sites. Except for the determinations pertaining to height growth, the conclusions of Meeuwig and Budy (1979) that were based on the 1977 plots, were supported by the data from the 1978 plots. More complex height growth patterns were found in the older stands. Competition may have a greater effect on height growth rates than we surmised from the 1977 plot data. The existence of a site-dependent maximum height on the 1978 plots was also indicated. The trees on the 1977 plots must have been well below maximum height for their sites because no indication of approach to maximum height was discernible.

Based on information obtained on the eight plots intensively measured so far, the following conclusions are offered:

1. Height growth rates depend on a complex combination of site quality, tree height, tree form, and competition. Height growth rates decrease as height approaches a site-dependent maximum. Height growth is usually slower in trees with a shrubby form and multiple leaders, which may be due to genetic make-up, insects, disease, approach to maximum height, or a combination of these. Competition affects height growth, but to a much lesser degree than it affects diameter growth.

2. Age has no direct effect on height growth rates. Some old trees have maintained constant height growth rates for the past century or more. Reduction in height growth rates in older trees is caused by approach to maximum height or, sometimes, by competition, insects or disease.

3. Diameter growth rates are regulated primarily by competition. The effects of site quality and genetic make-up on diameter growth of individual trees are obscured by competition and are probably much less important. As with height growth rates, diameter growth rates are not directly affected by age.

4. There are indications that, in the absence of competition, juniper is capable of more rapid diameter growth than pinyon and may be capable of more rapid height growth as well. However, junipers appear to be more sensitive to competition; they were dominated by pinyons on all five plots on which they occurred. Therefore, their true potentials could not be accurately evaluated.

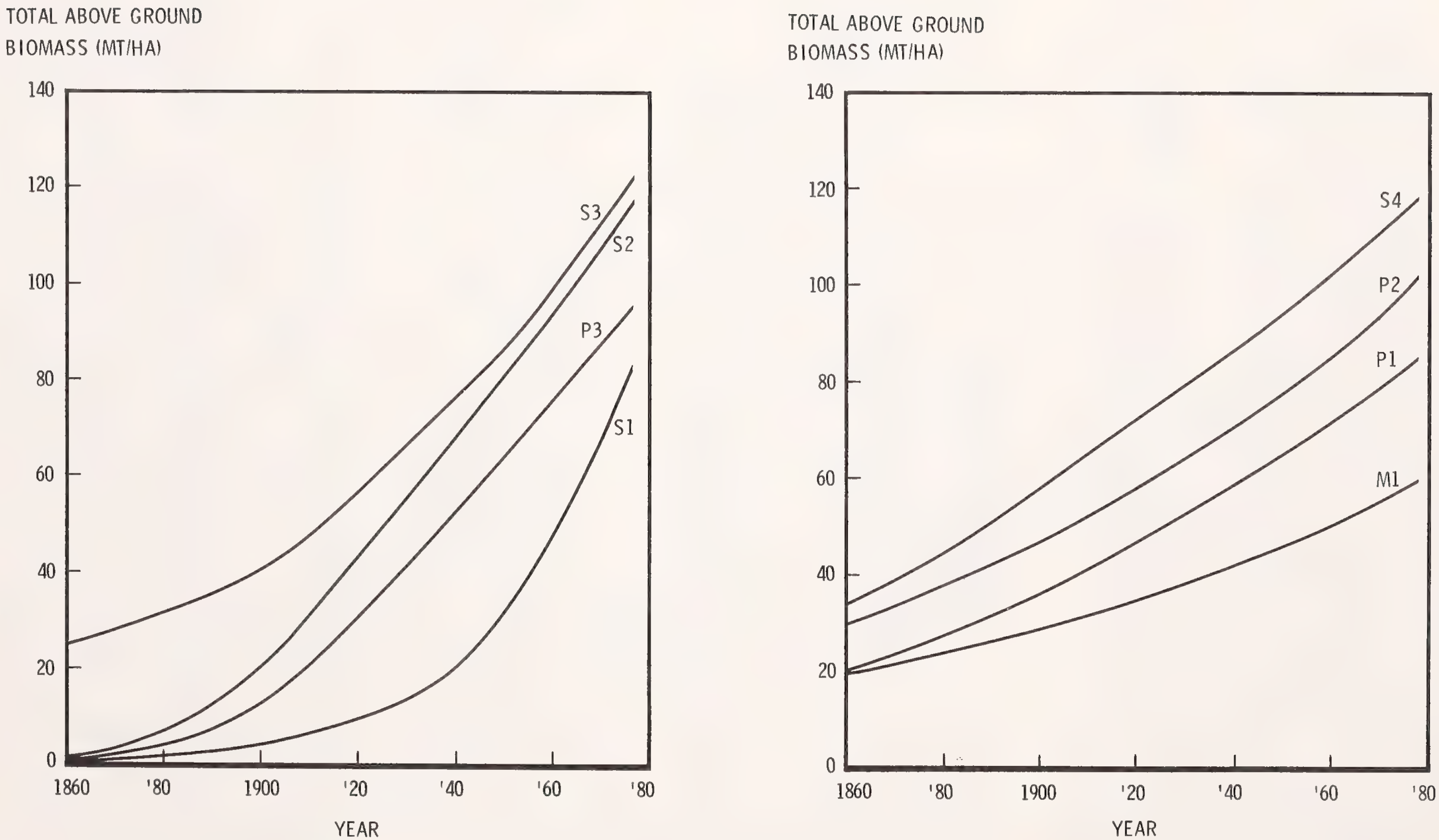


Figure 4.--Total aboveground biomass on the eight plots from 1860 to 1978.

5. Pinyon is capable of fully recovering from rather severe suppression.

6. Stand basal area increment had been remarkedly constant on all but the youngest plot for the past 60 years or more. The only plots with any indication that stand basal area increment might have been beginning to decline were, surprisingly, two of the younger plots. Because of its constancy and direct relationship to productivity, stand basal area increment appears to be a good index of site quality in closed stands.

7. Total aboveground biomass accumulation rates follow a pattern similar to stand basal area increment, but, because of continued height growth, there is a tendency for the rates to continue to increase even in the oldest stands. Since competition rarely kills larger pinyon and juniper, biomass accumulation can be expected to continue at nearly constant or slightly increasing rates for several centuries, barring tree cutting, fires, or epidemics.

These conclusions are tentative and subject to modification when more data are acquired. The conclusions pertaining to juniper are rather tenuous because few junipers were on the plots. Conclusions concerning effects of age on growth should be tested by measuring old stands on better sites, if such stands can be found.

# APPENDIX A: EQUATIONS OF ESTIMATING BIOMASS

The regression equations in this appendix and in appendix B were derived from data obtained by Miller, Budy, and Meeuwig (manuscript in preparation). These equations are based on 68 pinyon and 30 juniper trees on 13 sites throughout Nevada and 3 sites in eastern California. Biomasses are expressed in kilograms ovendry basis.

*Symbols*

$Y_1$ = Ln [total aboveground biomass]

$Y_2$ = Ln [wood (bark excluded) larger than 76 mm diameter]

$Y_3$ = Ln [foliage]

$X_1$ = Ln [diameter outside bark at stump height (cm)]

$X_2$ = Ln [total height (dm)]

$X_3$ = Ln [maximum crown diameter (dm)]

$X_4$ = Ln [average crown diameter (dm)]

$X_5$ = Ln [foliage class (defined in appendix D]

SDR = Standard deviation from regression

*Pinyon*

$$Y_1 = 2.416X_1 + 0.463X_2 + 1.776X_3 - 0.243X_1X_3 - 8.429$$

$R^2 = 0.988$ SDR = 0.148

$$Y_2 = 3.167X_1 + 2.827X_2 - 0.408X_1X_2 + 0.120X_1X_3 - 14.141$$

$R^2 = 0.991$ SDR = 0.163

$$Y_3 = 0.486X_1 + 0.470X_2 + 1.287X_4 + 0.396X_5 - 5.504$$

$R^2 = 0.936$ SDR = 0.267

*Juniper*

$$Y_1 = 0.850X_1 + 0.642X_2 + 1.392X_4 - 5.805$$

$R^2 = 0.969$ SDR = 0.199

$$Y_2 = 1.366X_2 + 0.336X_1X_4 - 6.289$$

$R^2 = 0.957$ SDR = 0.279

$$Y_3 = 0.137X_1X_2 + 1.278X_4 - 3.053$$

$R^2 = 0.919$ SDR = 0.258

# APPENDIX B: PROCEDURE FOR CALCULATING PAST BIOMASS

Diameter and height can be used to estimate past biomass because they can be determined for any time in the past by stem analysis. Crown parameters cannot be used as they were for present biomass because their past values cannot be estimated accurately. The following equations were developed to estimate past biomass:

*Pinyon*

$$Y = 2.695X_1 + 0.670X_2 - 0.0806X_1X_2 - 5.258$$

$$R^2 = 0.978 \qquad SDR = 0.205$$

*Juniper*

$$Y = 4.155X_1 + 2.435X_2 - 0.5473X_1X_2 - 11.504$$

$$R^2 = 0.926 \qquad SDR = 0.308$$

The natural log of total aboveground biomass (kg), ovendry basis is Y. Natural logs of stump diameter and total height (determined by stem analysis as described in the Methods section) are $X_1$ and $X_2$.

The last term (the intercept) in the equations was not used in the calculation of past biomass. A new intercept was calculated for each tree such that biomass calculated for 1978 equaled the estimated biomass as calculated by the more accurate equations in appendix A. For the pinyon equation, the proper intercept term (I) was calculated by:

$$I = Y_1 - 2.695X_1 - 0.670X_2 + 0.0806X_1X_2$$

in which $Y_1$ is the natural log of total aboveground biomass in the particular tree as calculated by the first equation in appendix A and $X_1$ and $X_2$ are logs of stump diameter and height measured in 1978. Intercept values for juniper trees were calculated similarly.

# APPENDIX C: CROWN MAPS

Crown maps for the five plots measured in 1978 are shown in figures 5 through 9. The plots are 30 m square. Pinyon stem centers are designated by an "x." An asterisk "*" indicates a juniper stem center.

All trees taller than 2 m are numbered and their crown outlines are shown. Locations and heights of trees between 1 dm and 20 dm are marked on the map, but they are not numbered and their crown outlines are not shown. Heights of these trees are given in decimeters. For example, "J13" signifies a juniper 13 dm tall.

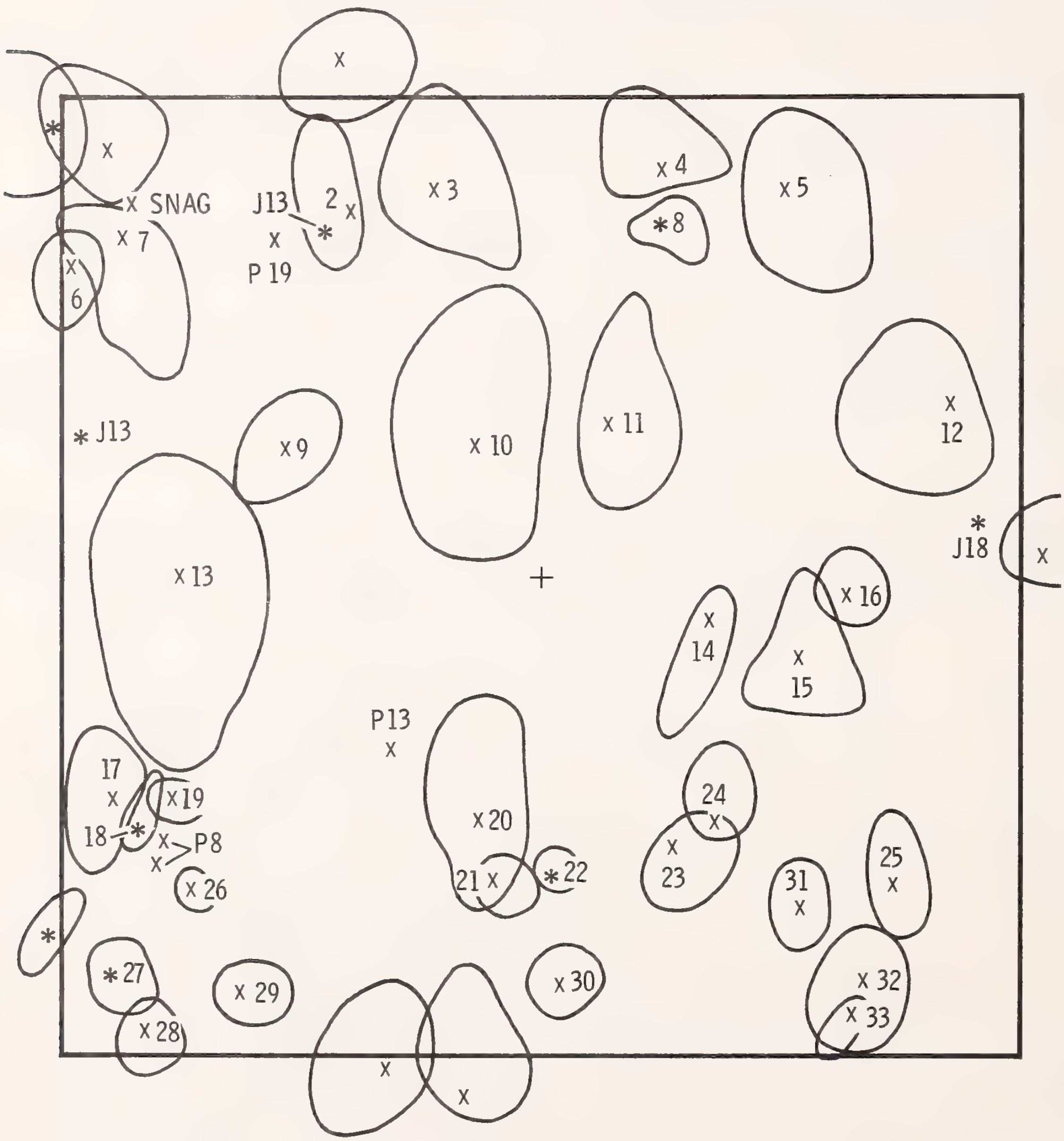


Figure 5.--Crown map of plot S4.

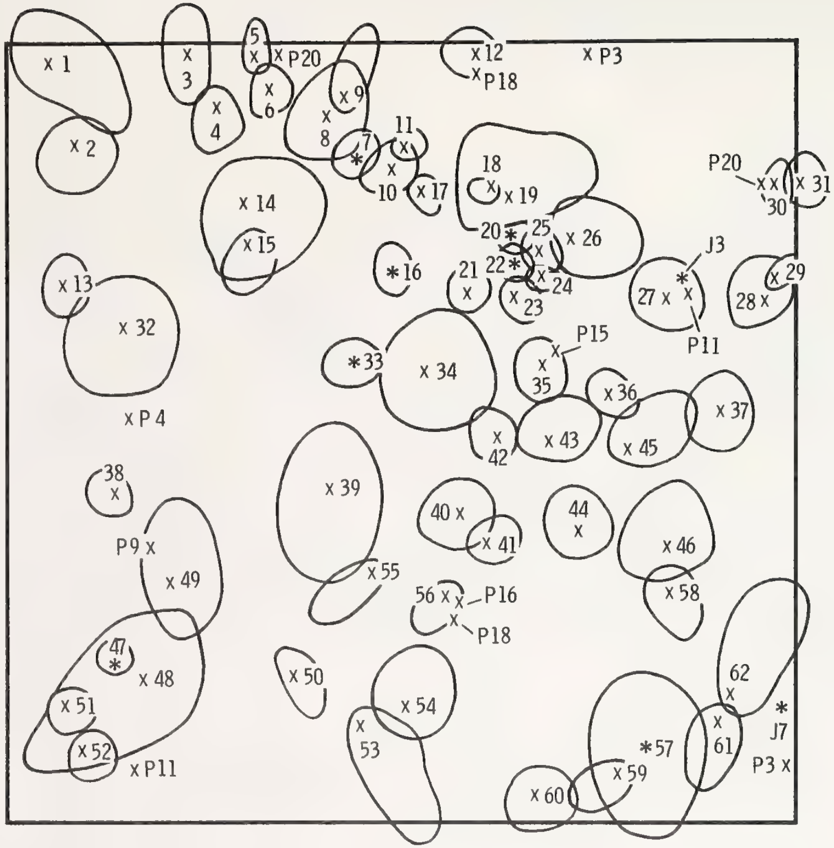


Figure 6.--Crown of plot P1.

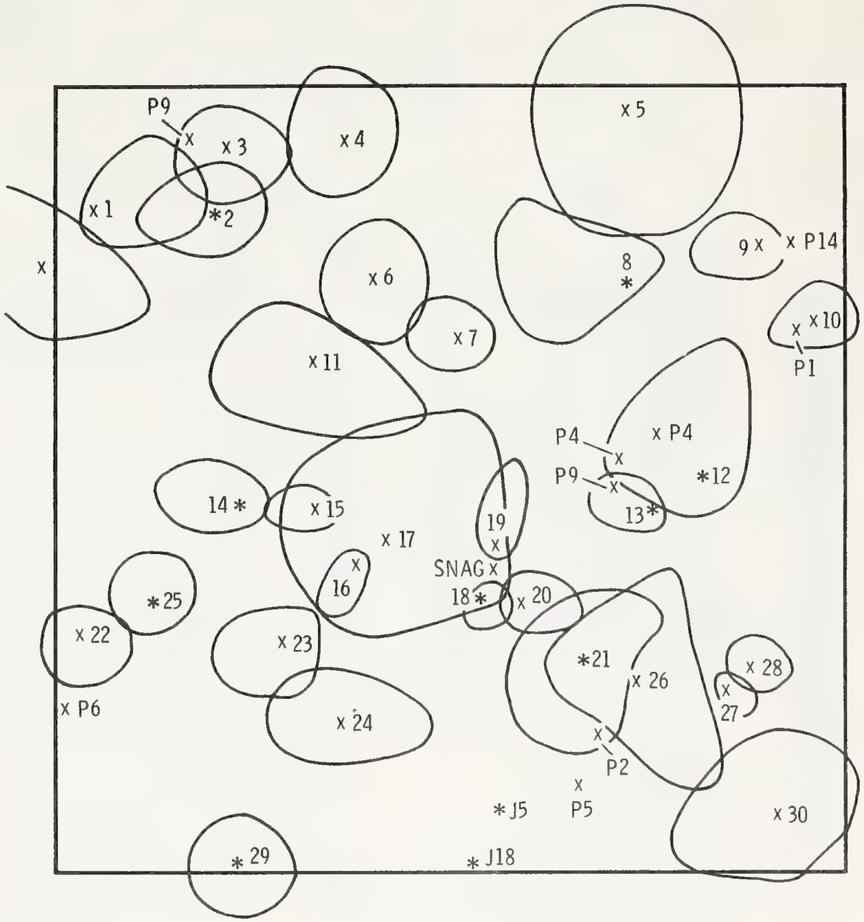


Figure 7.--Crown map of plot P2.

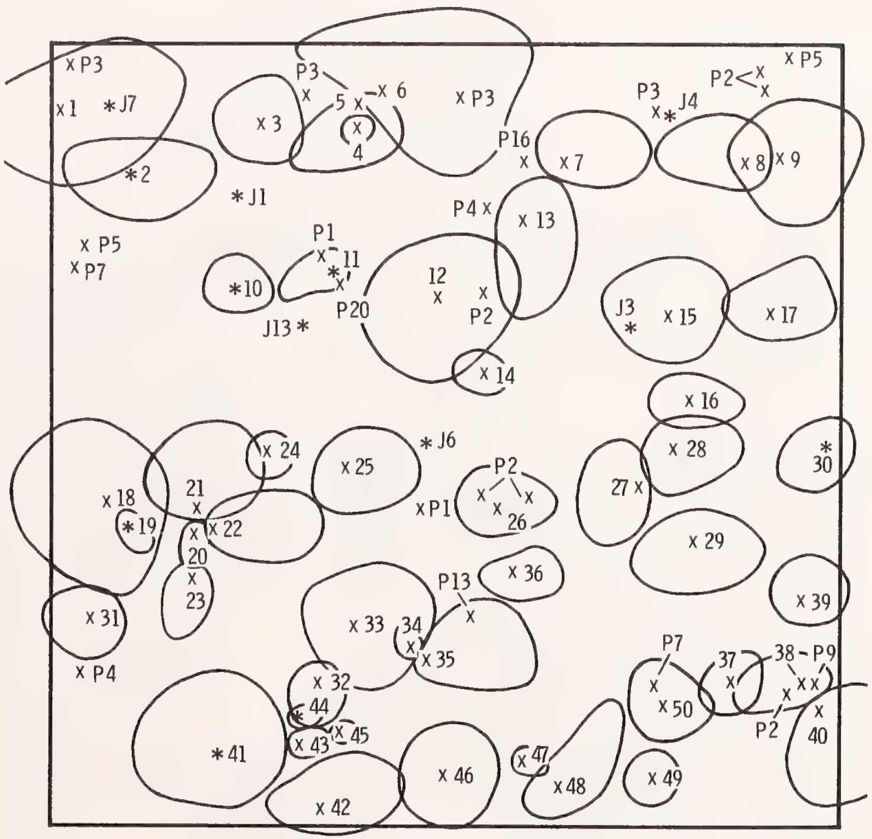


Figure 8.--Crown map of plot P3.

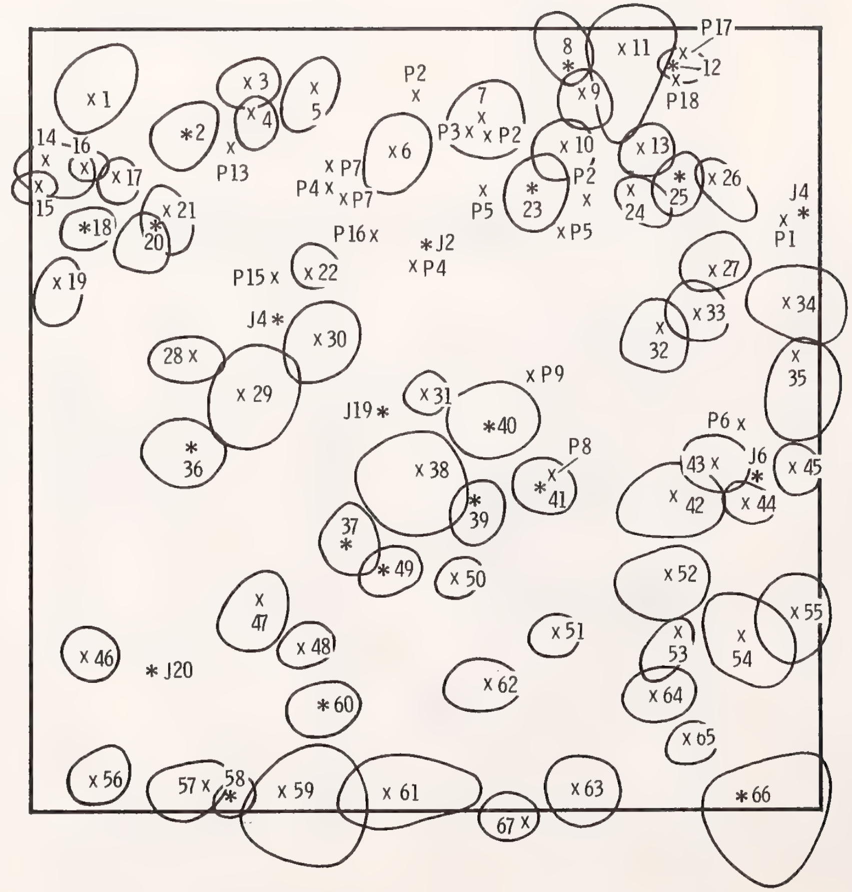


Figure 9.--Crown map of plot M1.

# APPENDIX D: TREE DATA

The measured and calculated data for trees taller than 2 m on the five plots measured in 1978 are in tables 4 through 8. The first column is tree number as shown on the crown maps. The second column is species: P for *Pinus monophylla* and J for *Juniperus osteosperma.* The third column is diameter measured outside bark at stump height (15 cm). The fourth column is total height. Maximum crown diameter is in column 5. The crown diameter perpendicular to the axis of maximum crown diameter is in column 6.

Foliage class is an ocular estimate of foliage density on a scale of 1 to 9. A tree with dense foliage on all sides would be rated 9 and a tree with few live branches would be rated 1.

Total age was estimated by extrapolating the height age curves to the ground surface. Height growth rates of seedlings are generally low; so the extrapolation procedure may slightly underestimate total age.

The biomasses in the next three columns were calculated with the regression equations in appendix A. The last column is diameter growth during the 10 years from 1966 through 1975.

Table 4.--*Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot S4*

| Tree number | Species[1] | Diameter | Height | Crown Max. | Crown Min. | Foliage class | Age | Biomass Foliage | Biomass Wood | Biomass Total | Diameter growth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *cm* | *dm* | *dm* | *dm* | | *Years* | *kg* | *kg* | *kg* | *mm/10 yrs* |
| 1 | P | 42 | 78 | 46 | 38 | 3 | 348 | 37 | 165 | 385 | 6 |
| 2 | p | 44 | 76 | 48 | 17 | 2 | 365 | 19 | 170 | 410 | 9 |
| 3 | P | 50 | 94 | 60 | 42 | 3 | 369 | 56 | 326 | 679 | 11 |
| 4 | P | 40 | 88 | 44 | 33 | 3 | 314 | 33 | 166 | 353 | 17 |
| 5 | P | 48 | 100 | 60 | 42 | 4 | 420 | 63 | 322 | 653 | 21 |
| 6 | P | 30 | 47 | 33 | 20 | 2 | 290 | 11 | 35 | 129 | 8 |
| 7 | P | 49 | 107 | 64 | 32 | 1 | 342 | 33 | 377 | 736 | 9 |
| 8 | J | 15 | 38 | 24 | 19 | 2 | 164 | 9 | 4 | 21 | 7 |
| 9 | P | 28 | 72 | 37 | 25 | 3 | 280 | 19 | 64 | 165 | 11 |
| 10 | P | 64 | 98 | 84 | 50 | 3 | 377 | 89 | 625 | 1 265 | 10 |
| 11 | P | 49 | 111 | 70 | 28 | 3 | 364 | 50 | 408 | 801 | 6 |
| 12 | P | 44 | 78 | 56 | 50 | 4 | 278 | 57 | 190 | 477 | 18 |
| 13 | P | 62 | 107 | 100 | 55 | 3 | 383 | 107 | 691 | 1 414 | 18 |
| 14 | P | 31 | 50 | 51 | 13 | 2 | 180 | 12 | 50 | 214 | 22 |
| 15 | P | 57 | 91 | 44 | 33 | 3 | 319 | 41 | 334 | 620 | 13 |
| 16 | P | 24 | 54 | 24 | 21 | 2 | 243 | 9 | 25 | 72 | 8 |
| 17 | P | 31 | 72 | 46 | 24 | 3 | 318 | 23 | 83 | 234 | 9 |
| 18 | J | 28 | 62 | 25 | 10 | 3 | 280 | 11 | 11 | 34 | 8 |
| 19 | P | 12 | 48 | 16 | 14 | 5 | 116 | 5 | 5 | 14 | 10 |
| 20 | P | 45 | 84 | 67 | 33 | 3 | 307 | 46 | 238 | 596 | 15 |
| 21 | P | 13 | 48 | 20 | 20 | 4 | 108 | 7 | 6 | 21 | 19 |
| 22 | J | 8 | 42 | 13 | 12 | 3 | 81 | 4 | 2 | 7 | 15 |
| 23 | P | 30 | 78 | 34 | 24 | 4 | 193 | 21 | 75 | 169 | 20 |
| 24 | P | 31 | 87 | 30 | 23 | 3 | 212 | 18 | 93 | 174 | 12 |
| 25 | P | 32 | 74 | 39 | 19 | 3 | 215 | 18 | 85 | 211 | 16 |
| 26 | P | 14 | 27 | 15 | 12 | 4 | 105 | 3 | 2 | 12 | 21 |
| 27 | J | 23 | 58 | 23 | 21 | 3 | 121 | 14 | 12 | 44 | 14 |
| 28 | P | 22 | 80 | 22 | 21 | 3 | 137 | 12 | 40 | 71 | 24 |
| 29 | P | 26 | 71 | 24 | 20 | 2 | 145 | 10 | 45 | 94 | 20 |
| 30 | P | 19 | 46 | 23 | 22 | 3 | 115 | 9 | 12 | 43 | 16 |
| 31 | P | 30 | 66 | 27 | 18 | 2 | 185 | 11 | 55 | 129 | 12 |
| 32 | P | 46 | 82 | 40 | 32 | 2 | 242 | 27 | 188 | 389 | 15 |
| 33 | P | 15 | 46 | 22 | 10 | 3 | 115 | 5 | 8 | 29 | 23 |

[1]The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma.*

Table 5.--*Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot P1*

| Tree number | Species[1] | Diameter | Height | Crown Max. | Crown Min. | Foliage class | Age | Biomass Foliage | Biomass Wood | Biomass Total | Diameter growth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *cm* | *dm* | - - *dm* - - | | | *Years* | - - - - - *kg* - - - - - | | | *mm/10 yrs* |
| 1 | P | 35 | 77 | 60 | 33 | 3 | 163 | 36 | 129 | 371 | 18 |
| 2 | P | 19 | 58 | 30 | 28 | 4 | 159 | 15 | 20 | 66 | 14 |
| 3 | P | 25 | 75 | 37 | 18 | 3 | 157 | 15 | 53 | 138 | 12 |
| 4 | P | 24 | 61 | 25 | 21 | 3 | 132 | 11 | 31 | 80 | 26 |
| 5 | P | 14 | 53 | 21 | 9 | 3 | 123 | 4 | 9 | 27 | 11 |
| 6 | P | 20 | 60 | 19 | 16 | 3 | 140 | 7 | 19 | 42 | 12 |
| 7 | J | 9 | 28 | 20 | 16 | 3 | 98 | 5 | 1 | 9 | 15 |
| 8 | P | 23 | 64 | 40 | 25 | 3 | 143 | 17 | 38 | 123 | 19 |
| 9 | P | 15 | 54 | 36 | 14 | 2 | 137 | 7 | 12 | 54 | 11 |
| 10 | P | 16 | 60 | 24 | 19 | 3 | 131 | 8 | 13 | 38 | 22 |
| 11 | P | 12 | 39 | 13 | 10 | 2 | 130 | 2 | 3 | 9 | 10 |
| 12 | P | 11 | 32 | 23 | 19 | 3 | 123 | 5 | 2 | 15 | 11 |
| 13 | P | 10 | 30 | 23 | 16 | 3 | 95 | 4 | 2 | 13 | 25 |
| 14 | P | 39 | 70 | 50 | 45 | 3 | 213 | 40 | 127 | 348 | 10 |
| 15 | P | 16 | 29 | 24 | 17 | 2 | 207 | 5 | 4 | 28 | 6 |
| 16 | J | 12 | 28 | 19 | 14 | 3 | 116 | 5 | 2 | 10 | 17 |
| 17 | P | 16 | 48 | 15 | 12 | 1 | 123 | 3 | 8 | 21 | 5 |
| 18 | P | 10 | 23 | 11 | 9 | 2 | 123 | 1 | 1 | 4 | 5 |
| 19 | P | 25 | 64 | 54 | 39 | 3 | 190 | 29 | 50 | 189 | 16 |
| 20 | J | 7 | 26 | 13 | 11 | 3 | 98 | 3 | 1 | 4 | 11 |
| 21 | P | 21 | 54 | 17 | 16 | 2 | 221 | 6 | 17 | 40 | 5 |
| 22 | J | 7 | 36 | 14 | 12 | 2 | 88 | 3 | 1 | 6 | 13 |
| 23 | P | 12 | 44 | 19 | 15 | 3 | 130 | 5 | 5 | 17 | 9 |
| 24 | P | 10 | 39 | 12 | 10 | 3 | 118 | 2 | 2 | 7 | 12 |
| 25 | P | 28 | 66 | 19 | 15 | 2 | 257 | 7 | 43 | 83 | 4 |
| 26 | P | 22 | 78 | 37 | 30 | 4 | 157 | 23 | 47 | 120 | 26 |
| 27 | P | 14 | 36 | 30 | 28 | 4 | 113 | 10 | 5 | 32 | 20 |
| 28 | P | 20 | 66 | 30 | 24 | 4 | 118 | 15 | 27 | 74 | 22 |
| 29 | P | 11 | 47 | 16 | 10 | 2 | 83 | 3 | 4 | 12 | 18 |
| 30 | P | 11 | 44 | 19 | 14 | 2 | 110 | 4 | 3 | 13 | 14 |
| 31 | P | 13 | 40 | 20 | 17 | 3 | 108 | 5 | 4 | 18 | 18 |
| 32 | P | 38 | 61 | 48 | 44 | 3 | 206 | 35 | 98 | 301 | 21 |
| 33 | J | 13 | 34 | 24 | 18 | 3 | 113 | 8 | 3 | 17 | 17 |
| 34 | P | 35 | 64 | 48 | 44 | 3 | 257 | 35 | 90 | 277 | 4 |
| 35 | P | 10 | 20 | 24 | 20 | 3 | 132 | 4 | 1 | 11 | 7 |
| 36 | P | 9 | 22 | 21 | 18 | 3 | 95 | 4 | 1 | 8 | 18 |
| 37 | P | 14 | 32 | 30 | 25 | 3 | 108 | 8 | 4 | 32 | 36 |
| 38 | P | 28 | 58 | 20 | 16 | 1 | 226 | 6 | 35 | 80 | 4 |
| 39 | P | 38 | 86 | 61 | 39 | 3 | 262 | 44 | 171 | 433 | 12 |
| 40 | P | 27 | 88 | 30 | 27 | 2 | 250 | 16 | 71 | 135 | 9 |
| 41 | P | 13 | 56 | 21 | 17 | 3 | 153 | 6 | 8 | 24 | 9 |
| 42 | P | 14 | 58 | 21 | 18 | 2 | 224 | 6 | 10 | 26 | 9 |
| 43 | P | 46 | 66 | 34 | 25 | 2 | 365 | 19 | 133 | 307 | 7 |
| 44 | P | 32 | 64 | 29 | 24 | 2 | 254 | 14 | 60 | 147 | 9 |
| 45 | P | 35 | 74 | 38 | 26 | 2 | 275 | 19 | 99 | 236 | 7 |
| 46 | P | 41 | 76 | 41 | 35 | 2 | 271 | 27 | 142 | 329 | 12 |
| 47 | J | 5 | 24 | 13 | 13 | 2 | 56 | 3 | 1 | 3 | 13 |
| 48 | P | 52 | 99 | 86 | 45 | 1 | 325 | 49 | 436 | 978 | 5 |
| 49 | P | 32 | 83 | 55 | 26 | 3 | 253 | 29 | 114 | 307 | 8 |
| 50 | P | 18 | 60 | 31 | 15 | 3 | 222 | 9 | 19 | 63 | 9 |
| 51 | P | 10 | 20 | 18 | 18 | 3 | 163 | 3 | 1 | 7 | 12 |
| 52 | P | 16 | 48 | 19 | 18 | 3 | 153 | 6 | 8 | 26 | 6 |
| 53 | P | 42 | 69 | 58 | 26 | 1 | 333 | 20 | 150 | 433 | 10 |
| 54 | P | 40 | 70 | 36 | 32 | 3 | 258 | 26 | 113 | 268 | 25 |
| 55 | P | 14 | 42 | 35 | 15 | 3 | 125 | 8 | 7 | 43 | 14 |
| 56 | P | 36 | 68 | 23 | 15 | 1 | 236 | 7 | 75 | 152 | 4 |
| 57 | J | 42 | 64 | 65 | 45 | 3 | 352 | 66 | 83 | 271 | 13 |
| 58 | P | 30 | 70 | 30 | 20 | 2 | 265 | 13 | 63 | 148 | 9 |
| 59 | P | 13 | 34 | 27 | 17 | 3 | 112 | 6 | 4 | 25 | 10 |
| 60 | P | 16 | 39 | 27 | 23 | 5 | 115 | 10 | 7 | 36 | 35 |
| 61 | P | 32 | 76 | 34 | 19 | 3 | 290 | 17 | 84 | 191 | 5 |
| 62 | P | 33 | 85 | 56 | 30 | 3 | 304 | 33 | 129 | 336 | 13 |

[1]The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osterosperma*.

Table 6.--*Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot P2*

| Tree number | Species[1] | Diameter | Height | Crown Max. | Crown Min. | Foliage class | Age | Biomass Foliage | Biomass Wood | Biomass Total | Diameter growth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *cm* | *dm* | *dm* | *dm* | | *Years* | *kg* | *kg* | *kg* | *mm/10 yrs* |
| 1 | P | 28 | 68 | 48 | 39 | 3 | 265 | 30 | 65 | 206 | 14 |
| 2 | J | 20 | 59 | 48 | 36 | 3 | 126 | 29 | 20 | 93 | 32 |
| 3 | P | 27 | 64 | 46 | 37 | 4 | 170 | 30 | 52 | 177 | 30 |
| 4 | P | 36 | 70 | 48 | 42 | 4 | 221 | 40 | 107 | 299 | 23 |
| 5 | P | 54 | 86 | 94 | 83 | 4 | 267 | 128 | 415 | 1 038 | 23 |
| 6 | P | 32 | 77 | 46 | 42 | 3 | 303 | 34 | 98 | 257 | 12 |
| 7 | P | 37 | 70 | 34 | 28 | 2 | 309 | 19 | 95 | 224 | 5 |
| 8 | J | 22 | 41 | 65 | 50 | 3 | 244 | 40 | 20 | 127 | 18 |
| 9 | P | 26 | 61 | 35 | 25 | 4 | 255 | 19 | 42 | 129 | 17 |
| 10 | P | 25 | 52 | 35 | 28 | 3 | 231 | 16 | 30 | 111 | 15 |
| 11 | P | 55 | 87 | 80 | 48 | 3 | 376 | 73 | 399 | 934 | 16 |
| 12 | J | 41 | 57 | 68 | 54 | 3 | 341 | 73 | 81 | 300 | 15 |
| 13 | J | 35 | 50 | 31 | 21 | 3 | 350 | 20 | 19 | 69 | 11 |
| 14 | J | 33 | 60 | 44 | 29 | 3 | 207 | 33 | 33 | 118 | 6 |
| 15 | P | 26 | 70 | 27 | 18 | 2 | 294 | 10 | 47 | 108 | 6 |
| 16 | P | 19 | 50 | 28 | 15 | 3 | 275 | 8 | 15 | 55 | 9 |
| 17 | P | 69 | 97 | 94 | 88 | 3 | 350 | 141 | 733 | 1 487 | 15 |
| 18 | J | 14 | 31 | 19 | 17 | 3 | 268 | 7 | 3 | 14 | 9 |
| 19 | P | 29 | 67 | 36 | 16 | 3 | 263 | 14 | 59 | 160 | 14 |
| 20 | P | 31 | 95 | 32 | 22 | 3 | 305 | 19 | 102 | 184 | 12 |
| 21 | J | 39 | 58 | 71 | 53 | 3 | 355 | 70 | 75 | 282 | 5 |
| 22 | P | 17 | 44 | 34 | 32 | 5 | 117 | 16 | 11 | 55 | 22 |
| 23 | P | 39 | 92 | 42 | 40 | 3 | 273 | 37 | 166 | 333 | 13 |
| 24 | P | 44 | 96 | 63 | 35 | 3 | 292 | 48 | 268 | 593 | 14 |
| 25 | J | 22 | 34 | 33 | 29 | 6 | 83 | 17 | 8 | 48 | 57 |
| 26 | P | 53 | 110 | 82 | 62 | 3 | 395 | 96 | 500 | 1 011 | 23 |
| 27 | P | 14 | 28 | 20 | 13 | 1 | 150 | 3 | 3 | 18 | 7 |
| 28 | P | 12 | 33 | 25 | 20 | 4 | 105 | 7 | 3 | 20 | 34 |
| 29 | J | 29 | 44 | 41 | 38 | 3 | 128 | 30 | 21 | 99 | 19 |
| 30 | P | 43 | 90 | 76 | 55 | 4 | 175 | 78 | 251 | 642 | 33 |

[1]The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.

Table 7.--*Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot P3*

| Tree number | Species[1] | Diameter | Height | Crown Max. | Crown Min. | Foliage class | Age | Biomass Foliage | Biomass Wood | Biomass Total | Diameter growth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *cm* | *dm* | - - *dm* - - | | | *Years* | - - - - - *kg* | - - - - | | *mm/10 yrs* |
| 1 | P | 54 | 83 | 78 | 51 | 4 | 156 | 81 | 359 | 872 | 29 |
| 2 | J | 32 | 56 | 58 | 34 | 3 | 152 | 41 | 38 | 150 | 14 |
| 3 | P | 19 | 55 | 36 | 35 | 5 | 96 | 21 | 19 | 74 | 22 |
| 4 | P | 7 | 33 | 11 | 10 | 2 | 104 | 2 | 1 | 3 | 7 |
| 5 | P | 31 | 86 | 45 | 27 | 4 | 156 | 29 | 104 | 245 | 14 |
| 6 | P | 39 | 88 | 90 | 65 | 3 | 143 | 82 | 221 | 647 | 17 |
| 7 | P | 24 | 64 | 42 | 31 | 3 | 122 | 21 | 39 | 133 | 20 |
| 8 | P | 34 | 80 | 44 | 30 | 3 | 149 | 28 | 114 | 275 | 25 |
| 9 | P | 36 | 82 | 52 | 50 | 4 | 140 | 50 | 134 | 338 | 21 |
| 10 | J | 16 | 35 | 27 | 22 | 4 | 83 | 11 | 5 | 26 | 24 |
| 11 | J | 13 | 52 | 29 | 17 | 3 | 106 | 10 | 6 | 26 | 14 |
| 12 | P | 36 | 86 | 64 | 52 | 3 | 164 | 54 | 160 | 424 | 15 |
| 13 | P | 30 | 92 | 55 | 31 | 3 | 146 | 33 | 116 | 288 | 17 |
| 14 | P | 10 | 27 | 21 | 17 | 4 | 65 | 4 | 1 | 10 | 21 |
| 15 | P | 25 | 54 | 46 | 42 | 3 | 136 | 26 | 37 | 152 | 19 |
| 16 | P | 25 | 70 | 36 | 21 | 2 | 137 | 14 | 49 | 134 | 8 |
| 17 | P | 22 | 64 | 42 | 30 | 3 | 118 | 20 | 36 | 123 | 15 |
| 18 | P | 42 | 84 | 70 | 60 | 4 | 155 | 75 | 212 | 560 | 26 |
| 19 | J | 8 | 34 | 18 | 13 | 2 | 115 | 4 | 2 | 7 | 12 |
| 20 | P | 18 | 64 | 18 | 11 | 3 | 141 | 5 | 17 | 36 | 13 |
| 21 | P | 36 | 84 | 47 | 38 | 3 | 159 | 36 | 141 | 328 | 19 |
| 22 | P | 27 | 81 | 45 | 28 | 2 | 168 | 21 | 77 | 199 | 7 |
| 23 | P | 14 | 45 | 30 | 19 | 4 | 120 | 9 | 7 | 36 | 14 |
| 24 | P | 9 | 36 | 18 | 18 | 3 | 81 | 4 | 2 | 9 | 19 |
| 25 | P | 38 | 68 | 42 | 22 | 3 | 165 | 22 | 105 | 279 | 20 |
| 26 | P | 29 | 76 | 38 | 26 | 2 | 160 | 18 | 73 | 181 | 12 |
| 27 | P | 21 | 59 | 41 | 28 | 3 | 128 | 17 | 27 | 104 | 24 |
| 28 | P | 34 | 80 | 38 | 31 | 3 | 161 | 26 | 104 | 233 | 19 |
| 29 | P | 32 | 68 | 41 | 35 | 3 | 163 | 27 | 77 | 216 | 17 |
| 30 | J | 8 | 36 | 33 | 25 | 3 | 69 | 10 | 3 | 19 | 10 |
| 31 | P | 22 | 56 | 33 | 28 | 3 | 116 | 15 | 26 | 88 | 17 |
| 32 | P | 25 | 80 | 26 | 23 | 3 | 150 | 15 | 53 | 103 | 10 |
| 33 | P | 36 | 96 | 49 | 48 | 4 | 144 | 51 | 166 | 352 | 23 |
| 34 | P | 12 | 42 | 13 | 9 | 2 | 112 | 2 | 4 | 11 | 6 |
| 35 | P | 30 | 66 | 48 | 34 | 3 | 171 | 27 | 68 | 218 | 14 |
| 36 | P | 22 | 64 | 33 | 22 | 3 | 147 | 14 | 31 | 93 | 8 |
| 37 | P | 16 | 64 | 31 | 24 | 4 | 101 | 14 | 18 | 55 | 19 |
| 38 | P | 27 | 80 | 39 | 21 | 3 | 163 | 18 | 71 | 172 | 10 |
| 39 | P | 26 | 67 | 29 | 28 | 2 | 142 | 14 | 42 | 107 | 13 |
| 40 | P | 28 | 74 | 80 | 44 | 2 | 165 | 39 | 86 | 340 | 6 |
| 41 | J | 28 | 58 | 58 | 53 | 4 | 210 | 51 | 42 | 185 | 18 |
| 42 | P | 23 | 54 | 42 | 31 | 4 | 153 | 22 | 30 | 122 | 14 |
| 43 | P | 8 | 28 | 17 | 12 | 4 | 80 | 3 | 1 | 6 | 15 |
| 44 | J | 7 | 30 | 13 | 8 | 3 | 85 | 2 | 1 | 4 | 12 |
| 45 | P | 5 | 25 | 10 | 10 | 2 | 65 | 1 | -- | 1 | 9 |
| 46 | P | 27 | 71 | 40 | 39 | 3 | 163 | 26 | 58 | 162 | 19 |
| 47 | P | 8 | 33 | 14 | 10 | 2 | 105 | 2 | 1 | 5 | 3 |
| 48 | P | 36 | 91 | 55 | 24 | 3 | 164 | 31 | 166 | 389 | 13 |
| 49 | P | 10 | 42 | 21 | 21 | 5 | 88 | 7 | 3 | 14 | 23 |
| 50 | P | 22 | 65 | 34 | 31 | 3 | 159 | 18 | 33 | 99 | 15 |

[1]The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.

Table 8.--*Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot M1*

| Tree number | Species[1] | Diameter | Height | Crown | | Foliage class | Age | Biomass | | | Diameter growth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Max. | Min. | | | Foliage | Wood | Total | |
| | | *cm* | *dm* | - - *dm* - - | | | *Years* | - - - - - *kg* - - - - | | | *mm/10 yrs* |
| 1 | P | 20 | 52 | 37 | 26 | 4 | 158 | 16 | 19 | 82 | 19 |
| 2 | J | 16 | 45 | 29 | 21 | 4 | 190 | 12 | 7 | 32 | 7 |
| 3 | P | 18 | 57 | 23 | 19 | 3 | 161 | 9 | 17 | 46 | 21 |
| 4 | P | 15 | 46 | 20 | 14 | 3 | 125 | 5 | 7 | 25 | 15 |
| 5 | P | 21 | 48 | 30 | 18 | 3 | 280 | 10 | 17 | 67 | 7 |
| 6 | P | 30 | 53 | 33 | 24 | 3 | 356 | 16 | 43 | 139 | 7 |
| 7 | P | 24 | 54 | 30 | 29 | 3 | 196 | 15 | 27 | 90 | 17 |
| 8 | J | 11 | 31 | 32 | 30 | 3 | 219 | 12 | 3 | 25 | 4 |
| 9 | P | 23 | 43 | 29 | 20 | 3 | 285 | 10 | 18 | 74 | 7 |
| 10 | P | 12 | 36 | 23 | 20 | 3 | 173 | 6 | 3 | 19 | 10 |
| 11 | P | 37 | 75 | 53 | 36 | 4 | 334 | 42 | 131 | 366 | 8 |
| 12 | J | 18 | 52 | 18 | 13 | 2 | 256 | 7 | 6 | 20 | 6 |
| 13 | P | 16 | 38 | 21 | 20 | 3 | 266 | 7 | 6 | 27 | 7 |
| 14 | P | 25 | 61 | 30 | 20 | 3 | 287 | 13 | 37 | 105 | 10 |
| 15 | P | 11 | 30 | 16 | 10 | 2 | 192 | 2 | 2 | 10 | 10 |
| 16 | P | 11 | 28 | 15 | 11 | 3 | 166 | 3 | 1 | 9 | 7 |
| 17 | P | 13 | 34 | 17 | 16 | 2 | 187 | 4 | 3 | 14 | 8 |
| 18 | J | 14 | 31 | 20 | 16 | 3 | 240 | 7 | 3 | 14 | 6 |
| 19 | P | 22 | 47 | 27 | 19 | 2 | 276 | 8 | 19 | 69 | 5 |
| 20 | J | 15 | 28 | 23 | 23 | 4 | 202 | 9 | 3 | 20 | 9 |
| 21 | P | 22 | 58 | 26 | 20 | 3 | 271 | 11 | 24 | 69 | 6 |
| 22 | P | 8 | 31 | 20 | 18 | 4 | 101 | 4 | 1 | 8 | 10 |
| 23 | J | 12 | 40 | 30 | 24 | 4 | 239 | 11 | 5 | 26 | 5 |
| 24 | P | 16 | 41 | 24 | 16 | 2 | 178 | 5 | 7 | 32 | 7 |
| 25 | J | 20 | 48 | 26 | 18 | 3 | 223 | 12 | 8 | 33 | 5 |
| 26 | P | 17 | 58 | 30 | 15 | 2 | 263 | 7 | 16 | 55 | 10 |
| 27 | P | 19 | 54 | 26 | 21 | 3 | 275 | 10 | 17 | 53 | 8 |
| 28 | P | 30 | 65 | 28 | 18 | 3 | 288 | 13 | 56 | 135 | 10 |
| 29 | P | 35 | 69 | 41 | 33 | 4 | 308 | 30 | 95 | 251 | 9 |
| 30 | P | 36 | 64 | 32 | 27 | 3 | 309 | 20 | 81 | 200 | 8 |
| 31 | P | 22 | 51 | 17 | 16 | 2 | 234 | 6 | 18 | 44 | 5 |
| 32 | P | 22 | 49 | 27 | 25 | 3 | 245 | 12 | 19 | 66 | 11 |
| 33 | P | 14 | 46 | 25 | 22 | 4 | 184 | 9 | 7 | 28 | 12 |
| 34 | P | 33 | 72 | 37 | 27 | 3 | 287 | 22 | 83 | 206 | 6 |
| 35 | P | 34 | 51 | 39 | 29 | 2 | 315 | 18 | 58 | 199 | 8 |
| 36 | J | 13 | 24 | 30 | 27 | 3 | 180 | 10 | 3 | 22 | 8 |
| 37 | J | 18 | 33 | 27 | 23 | 3 | 280 | 12 | 5 | 29 | 7 |
| 38 | P | 31 | 66 | 45 | 41 | 3 | 270 | 30 | 73 | 222 | 8 |
| 39 | J | 12 | 33 | 25 | 20 | 3 | 197 | 8 | 3 | 18 | 9 |
| 40 | J | 34 | 34 | 36 | 29 | 3 | 305 | 22 | 14 | 72 | 10 |
| 41 | J | 20 | 42 | 24 | 20 | 4 | 251 | 11 | 7 | 31 | 9 |
| 42 | P | 30 | 58 | 41 | 30 | 3 | 293 | 22 | 54 | 179 | 6 |
| 43 | P | 15 | 38 | 27 | 22 | 3 | 187 | 8 | 6 | 33 | 11 |
| 44 | P | 11 | 36 | 20 | 16 | 3 | 126 | 4 | 3 | 13 | 18 |
| 45 | P | 24 | 45 | 20 | 17 | 3 | 280 | 8 | 18 | 56 | 18 |
| 46 | P | 15 | 22 | 22 | 20 | 1 | 294 | 3 | 2 | 19 | 2 |
| 47 | P | 30 | 54 | 33 | 24 | 4 | 295 | 18 | 44 | 139 | 10 |
| 48 | P | 22 | 45 | 20 | 18 | 1 | 232 | 5 | 15 | 48 | 11 |
| 49 | J | 12 | 31 | 23 | 17 | 4 | 203 | 7 | 2 | 15 | 9 |
| 50 | P | 17 | 38 | 19 | 16 | 3 | 182 | 5 | 7 | 27 | 10 |
| 51 | P | 16 | 42 | 20 | 17 | 4 | 132 | 7 | 8 | 29 | 21 |
| 52 | P | 24 | 51 | 35 | 27 | 3 | 265 | 15 | 27 | 103 | 11 |
| 53 | P | 16 | 34 | 27 | 15 | 3 | 244 | 6 | 6 | 34 | 8 |
| 54 | P | 32 | 66 | 42 | 31 | 4 | 270 | 28 | 75 | 217 | 10 |
| 55 | P | 29 | 59 | 33 | 28 | 4 | 266 | 20 | 47 | 139 | 10 |
| 56 | P | 24 | 58 | 27 | 22 | 3 | 280 | 12 | 28 | 81 | 6 |
| 57 | P | 25 | 58 | 30 | 21 | 2 | 267 | 11 | 34 | 102 | 7 |
| 58 | J | 7 | 28 | 19 | 13 | 4 | 149 | 4 | 1 | 6 | 5 |
| 59 | P | 42 | 76 | 49 | 46 | 3 | 288 | 43 | 162 | 401 | 9 |
| 60 | J | 12 | 36 | 27 | 21 | 2 | 175 | 9 | 30 | 20 | 11 |
| 61 | P | 37 | 68 | 53 | 27 | 4 | 297 | 32 | 114 | 336 | 7 |
| 62 | P | 20 | 57 | 31 | 21 | 3 | 192 | 12 | 21 | 71 | 13 |
| 63 | P | 21 | 60 | 29 | 27 | 4 | 220 | 16 | 26 | 76 | 19 |
| 64 | P | 17 | 33 | 27 | 21 | 3 | 208 | 8 | 6 | 37 | 11 |
| 65 | P | 14 | 37 | 19 | 17 | 2 | 206 | 4 | 4 | 20 | 17 |
| 66 | J | 28 | 35 | 54 | 50 | 1 | 265 | 37 | 20 | 122 | 3 |

[1]The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.



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Meeuwig, R. O.
1979. Growth characteristics of pinyon-juniper stands in the western Great Basin. USDA For. Serv. Res. Pap. INT-238, 22 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Stem analyses in singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stands in Nevada and eastern California indicate that tree age does not directly affect either diameter growth or height growth rates. Diameter growth rates are governed primarily by competition and height growth rates depend largely on genetic and site characteristics. Rates of stand basal area increment vary among stands but tend to be constant with time within closed stands. Total above-ground biomass accumulation rates tend to increase with time, even in older stands.

KEYWORDS: *Pinus monophylla, Juniperus osteosperma,* silvics, site index, biomass

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1979. Growth characteristics of pinyon-juniper stands in the western Great Basin. USDA For. Serv. Res. Pap. INT-238, 22 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Stem analyses in singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stands in Nevada and eastern California indicate that tree age does not directly affect either diameter growth or height growth rates. Diameter growth rates are governed primarily by competition and height growth rates depend largely on genetic and site characteristics. Rates of stand basal area increment vary among stands but tend to be constant with time within closed stands. Total above-ground biomass accumulation rates tend to increase with time, even in older stands.

KEYWORDS: *Pinus monophylla, Juniperus osteosperma,* silvics, site index, biomass

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